SIMULATION MODELLING OF SUPPLY CHAIN PROCESSES – A CASE STUDY FROM WHOLESALE

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Abstract

In today's global market the main focus of competition is not only between different companies but also between supply chains. The paper shows that technological changes are important for effective supply chain management, however, the main cause of supply chain improvements are organizational changes and an integration of business processes that lead to more mature processes in all involved companies and at the supply chain level. It can be realized by using effective business process management methods that include estimation of process maturity, modelling, process analysis and performance measurement, continuous improvement etc. The concepts are illustrated with a case study of Merkur supply chain in which already introduced changes are evaluated with simulation modelling and process maturity measurement methods. Three different versions of the process were modelled: the process before IS implementation (AS-WAS); the current process (AS-IS), where several activities were automated; and the proposed redesigned process (TO-BE), where more radical changes are planned that require several organisational changes. The case shows that business process management on the supply chain level brings benefits to all companies involved. The decrease in work costs and reduction in process and lead times begins with IT implementation and the increase in maturity. However, in order to further improve the process, more considerable organisational changes are needed. It can be seen from the case study that business process modeling and discrete-event simulation are valuable mechanisms for realizing the actual business value of business-to-business e-commerce.

Keywords: Supply chain management, Business process management, Business process orientation, Process maturity, Business process simulation modelling.

Presenting Author's biography

Jurij Jaklic received his Master Degree in Computer Science in 1992 from the University of Houston and his PhD in 1997 from the University of Ljubljana, Slovenia. Currently he is an associate professor at the Faculty of Economics, University of Ljubljana. His main research interests are business process renovation, e-business, decision support systems, and data and business process modelling.

1 Introduction

In today's global market the main focus of competition is not only between different companies but also between supply chains. A supply chain (SC) not only includes manufacturers and suppliers, but also transporters, warehouses, retailers and customers [1]. There are many important issues and problems that need to be resolved for successful and efficient SC operation – this is the main purpose of supply chain management (SCM). Storey et al. [2] argue that there is a substantial gap between theory and practice of SCM. They suggest that business models and SC practices have to be changed simultaneously.

Efficiency of SCs can generally be improved by e.g. reducing the number of manufacturing stages, reducing lead-times, working interactively rather than independently between stages, and speeding up the information flow [3]. One of the commonly applied methods in SCM is vendor-managed inventory (VMI) or similar concepts such as efficient consumer response (ECR), continuous replenishment (CR), collaborative planning, forecasting, and replenishment (CPFR) [4] and synchronized consumer response (SCR). A problem is that companies often tend to optimise their own performance, disregarding the benefits of a SC as a whole (local instead of global optimisation). A prerequisite for effective SCM is long-term contracts, partnership and established e-business connections between the companies in the SC. Indeed, the lack of trust between business partners is one of the main hindrances to collaboration in the SC context [5],[6]. One of the related challenges is who should be responsible for managing the SC [2].

A majority of SCM problems either stems from uncertainties or inability to coordinate several activities and partners. Sharing of information can obviously be a problematic issue as the companies in a SC may not be prepared to share their production data, lead times, specially when those companies are independent of each other [7]. Thus, another possibility to improve the efficiency of SCs is implementation of information technology (IT). Although IT improves the flows of information and allows better communication between parties, organisational and system factors such as process definitions and legacy systems are also important [8]. The barriers to the adoption of inter-organisational information systems do not lie primarily in the technology but in business processes. The implementation of inter-organisational systems only leads to full advantage if introduced hand-in-hand with business process renovation in a whole SC [9].

As evident from the discussion above, the key issue for successful SCM is integration of business processes, such as purchasing and customer relations. Even in the most successful companies there are few fully integrated processes [10].

The purpose of this paper is to analyse how SC efficiency is related to BPO that is measured by SC maturity level. On one side higher level of BPO is a prerequisite for significant changes, integration, and efficiency improvements of SC business processes. On the other side process changes are enablers for higher SC process maturity. Lockamy & McCormack [11] claim that integrated SC management may be more difficult to operationalise in practice than in theory. Therefore we analyse how to operationalise the relationship between SC maturity and SC performance.

The paper shows that technological changes are important for effective SCM, however, the main cause of SCM improvements is organisational changes and integration of business processes that lead to more mature processes in all involved companies and at the SC level. It can be implemented by using business process management (BPM) methods that include estimation of process maturity, modelling, process analysis and performance measurement, continuous improvement etc.

SC performance can be assessed by using simulation modeling. The reasons for the introduction of simulation modeling into process modeling can be summarized as follows: simulation allows for the modeling of process dynamics, the influence of random variables on process development can be investigated, re-engineering effects can be anticipated in a quantitative way, process visualization and animation are provided, and simulation models facilitate communication between clients and an analyst. The final reason for using simulation modeling is the fact that it can be increasingly used by those who have little or no simulation background or experience [12].

The concepts are illustrated and analysed with a case study of a SC of a large Slovenian wholesaler and retailer. In the case study changes are evaluated by simulation modelling and process maturity measurement methods. Besides, several possible future improvements are analysed.

2 Increasing Maturity of Supply Chain Processes with Business Process Management

To cope with challenges, organisations, especially those that wish to successfully manage their SCs, have to accept process-based management principles, as SCM is based on process view on business [10]. The process paradigm implies a new way of looking at organisations based on the processes they perform rather than on the functional units they are divided into.

A process is a set of one or more linked procedures or activities that collectively realise a business objective by transforming a set of inputs into a specific set of

outputs (goods or services) for another person (customer) by a combination of people, methods, and tools [13], [14]. Procurement and fulfilment are the key processes in a SC and with the onset of the Internet those, which have to be first and foremost redesigned and reorganised [15]. In fact, process improvement orientation is the most often used construct in research connected with SCM and the majority of research papers frame SCM as sort of a process [16].

To analyse the understanding of processes of a company and a SC the concept of business process orientation (BPO) can be used. The concept denotes an organisation that, in all its thinking, emphasises processes as opposed to hierarchies with a special emphasis on outcomes and customer satisfaction [10]. It consists of several components: process view, process jobs and process management and measurement. Process view involves a focus on processes across an organisation that need to be defined and understood by the employees. Functional roles and titles reflecting the traditional hierarchical structure are replaced by process owners – leaders who are responsible and accountable for the operation and improvement of the core business [14]. Along with process owners, process teams become the main building element of an organisation which emphasises the process job category. Finally, process management, supplemented with process measures, has as much to do with changing the culture and the way of thinking, as it does with changing the organisational structure.

Levels of process orientation are often presented by a process maturity concept, which serves as a reference model of the stages that organisations go through as they move from being immature to mature in their process orientation. Hueffner [17] state that increased process maturity is correlated with an increased probability of achieving effectiveness, efficiency and quality and that increased maturity can lead to a decreased gap between objectives and the current situation.

The SC maturity model [18] is an extension of BPO concept to a SC. The purpose of the model is to assess at which stage a SC is and to assist in developing a road map. For measuring the maturity of SC processes several methods can be applied, like questionnaires, interviews, documentation review, etc. The SC maturity model defines the following levels:

- **Level 1 – Ad hoc**: The SC and its practices are unstructured and ill-defined. Processes, activities and organisational structures are not based on horizontal processes, process performance is unpredictable. SCM costs are high, customers satisfaction is low, functional cooperation is also low.
- **Level 2 – Defined**: Basic SCM processes are defined and documented, yet the activities and organisation basically remain traditional. SCM costs remain high, customer satisfaction has improved, but is still low.
- **Level 3 – Linked**: This level represents a breakthrough. Cooperation between company departments, vendors and customers is established. SCM costs begin decreasing and customer satisfaction begins to show marked improvement.
- **Level 4 – Integrated**: The company, its vendors and suppliers cooperate in the process level. Organisational structures are based on SCM procedures, SCM performance measures and management systems are applied. Advanced SCM practices, like collaborative forecasting with other members of a SC, form. As a consequence, SCM costs are dramatically reduced.
- **Level 5 – Extended**: Competition is based on SCs. Collaboration between companies is on the highest level, multi-firm SCM teams with common processes, goals and broad authority form.

In [18] the relationship between SC processes maturity and overall SC performance is examined. The research showed that SCM process performance is strongly related to SC processes maturity. Additionally, the research indicates that direct process measures like cycle times and inventory levels are also related to the maturity of SC processes. The purpose of this research is to analyse the relationship between process efficiency and SC maturity in more depth.

SCM initially emphasised local optimisation of each SC activity, or more specifically, the lowering of costs and increasing the level of services at each stage [19]. As the ultimate customer perceives the output of an entire SC as a unique product and/or service, a similar transition to that from a functional to a process view inside a company has to be done at the SC level. This is a transition from inter-organisational linkages to truly integrated and managed inter-organisational processes. They have to be designed in a way that a SC can react to the changing needs of their customers, to new business models of their competitors, and opportunities of new technologies [8].

The transition from inter-organisational linkages to process-orientation takes many forms. Business process (re)design is one of the most common forms of organisational change [20]. It is a strategy that critically examines current business policies, practices and procedures, rethinks them and then redesigns the mission-critical products, processes, and services [21]. It also means analysing and altering the business processes of the organisation as a whole and requires careful change management. In SCM terms an important aspect is to guide process renovation with the idea to simplify and improve processes in a way

that they can be more easily integrated with other companies. Nowadays, e-business renovation [22] strategies focus on the processes between business partners and the applications supporting these processes.

While BPM enables a shorter cycle-time and lower costs of transactions, it also means the reduction in inventory levels (safety stock) for all companies in a SC without increasing the danger of stock-outs. The findings of an empirical research presented in [4] indicate that high levels of information exchange and structural collaboration, upstream as well as downstream are necessary for any substantial performance improvements. Gradual changes will not result in noteworthy rates of performance advances.

Permanent tracking of SC measures and continuous tuning of processes is necessary for a continuous process analysis and improvements. It also enables some strategic advantages besides the advantages at the operational/tactical level. The effectiveness of the process can be achieved and evaluated only by long-term measurement and continuous improvement of processes [23].

Performance measures should be integrated across different departments and all companies in the SC [6][23]. Developing measures of SC relationships and the SC as a whole, rather than measures of intra-organisational performance, is vital [24]. However, changes in a single company should also be studied, because a company is unlikely to participate in an integration project if it does not bring benefit to that company as well. In some cases it is difficult to measure performance indicators on-site. For redesigned processes that are to be implemented, or for the evaluation of different alternative renovation scenarios this is also impossible. Simulations can be used to estimate performance indicators in these cases.

3 Measurement of Supply Chain Maturity and Process Efficiency

Based on the previously presented theoretical background we analyse in more depth the relationship between SC maturity and SC process performance.

As previously discussed, the SC maturity can be considered as a measure for BPO of a SC. Thus an increase in the SC maturity level can be operationalised via the improvement of BPO using different (business process) management practices. Similarly, process efficiency can be improved by business process change methods [3]. Consequently, the relationship between the SC maturity level and SC process performance can be, at the operationalisation level, observed through the relationship between BPO improvement practices and process change.

In the case study a part of the SC (presented in the next section) was studied at three stages, i.e. at three different points in time: past, present, and future. The SC has already evolved from the first to the second stage, while the transition to the next stage was analysed as a part of this research.

The SC maturity level was evaluated by use of a questionnaire. It is based on the questionnaire for BPO in a SC developed by McCormack & Johnson [10]. It consists of several variables that measure different dimensions of BPO, namely process view, process jobs, process management as well as measurement and processes in a SC. Process view involves a focus on the workflows and processes across an organization. Functional roles and titles reflecting the traditional hierarchical structure are replaced by process owners – leaders who are responsible and accountable for the operation and improvement of the core business. Along with process owners, process teams become the main building element of an organization which emphasizes the process job category. Finally, process management, supplemented with process measures, has as much to do with changing the culture and the way of thinking, as it does with setting process oriented measures and goals for an organization. Some questions relating to IT deployment and information flow in a SC were added to the original BPO questionnaire. Additionally, the processes in a SC were analysed by using the questions originated from the work of McCormack & Johnson [10]. The five-point Likert scale (1 – completely disagree, 5 – completely agree) was used.

Models of business processes play an important role in different phases of BPM regardless of the methodology used [25]. Business process modelling and the evaluation of different alternative scenarios for the improvement by simulation are usually the driving factors of a business renovation process [22].

Many different methods, techniques and tools can be used for the modelling of business processes in order to give an understanding of possible scenarios for improvement [26]. The most promising technique is Business Process Diagram (BPD) that is part of a Business Process Modelling Notation (BPMN) standard developed by the Business Process Management Initiative (BPMI) [27]. The technique is supported by a majority of contemporary business process modelling tools and is also used in the case study presented in the next section.

Business process simulation modelling was used for the purpose of SC efficiency evaluation. Simulation is used to understand the behaviour of a concrete system and/or to evaluate various strategies for the operation of the system [28]. The most often used type of simulation in a business process renovation project is discrete event simulation (DES). DES allows system quantities (state variables of attributes) to change only at discrete points in time, called events. DES provides for the understanding of the essence of business systems, the processes for a change to be identified, process visions to be developed, new processes to be

designed and prototyped and the impact of proposed changes in terms of lead-times and costs to be evaluated [29]. The methodology, advantages and some problems of this approach are presented in more depth in [22]. However, this methodology does not enable direct measurement of the process quality and/or its outputs [9].

The data regarding business processes (e.g. activities, costs, lead-times) were acquired during business process modelling and were provided by the companies involved in the SC on an interview basis. Since business process models are an abstraction of SC operations, it was vital for the case study to ensure that the business process simulations fit the realistic SC operations. The data quality was cross-checked and fine tuned when comparing the results of business process simulations with real life data. The data for simulation of the proposed TO-BE process model were estimated in several iterations by domain experts (process actors and managers).

The two major measures used in this research to evaluate SC efficiency are lead times and process costs. Lead times are especially important because they are one of the most critical parameters in the evaluation of process efficiency. Their estimation can be based on experience, calculations in the ERP system, or monitored actual time [30]. In our case the activity times are actual times, while the total times were estimated with simulations.

Strategic costs reduction and consideration of total costs in supplier selections are considered one of the top trends in SCM [31] and as discussed earlier one of the most often used performance indicator in a SC.

4 Case study: Wholesaler Supply Chain

The above-described concepts were analysed with the case study that analyses a part of the SC of the large Slovenian wholesaler and retailer Merkur. It includes their sales process that involves other companies, namely: "Customer" – any company that buys products from Wholesaler; "Supplier" – performs activities in case of transit order; and "Transporter" – performs the necessary transport of goods. Since the case does not include the whole SC, the concepts can be used even if there are more participating companies.

4.1 The company Merkur, d.d. and it's B2B business activities

The company Merkur, d.d. is a wholesale and retail company trading with technical products. The basic processes in a trade company are: purchasing, warehousing and sales of goods.

Merkur's sales programme consists of 200.000 different items, which are purchased from about 2.000 suppliers. Business relations with top 1.000 suppliers are regulated with purchasing contracts. About 97% of total purchase is carried out with these suppliers. With top 200 suppliers, 80% of total purchasing is performed. Merkur produces about 300.000 purchase documents with 1.200.000 items annually.

Wholesale sales are processed in Wholesale, Retail and Sales to Foreign Markets departments. Sales to end consumer are carried out only from the Retail department. Wholesale sales represent about 75% of total Merkur revenues.

Merkur has business relations with 22.000 wholesale buyers / businesses. The Wholesale Department takes care of the biggest 2.500 buyers, The Sales to Foreign Markets Department is in charge of buyers from outside Slovenia, all other smaller Slovenian buyers are served by the Retail Department. The Wholesale Department processes more than 700.000 sales documents with 4.000.000 items each year.

Considering this data it is clear that business relations between Merkur and its partners in the B2B segment are very close and the frequency of data interchange is high; therefore, it is necessary to computerize the processes in order to speed them up, cut costs and eliminate errors.

4.2 Strategic development programme "Merkur's E-business with Companies – B2B"

Merkur's business strategy is brought to effect through strategic development programmes which usually last for several years. Strategic development programmes are structured in projects, which makes the resolution of complex problems with partial step-by-step solutions possible.

One of Merkur's strategic development programmes is called "Electronic business between Merkur and partners – B2B". The programme has the following objectives:

- Possibility of permanent commercial business between Merkur and its partners on 24x7 basis.
- Possibility of electronic business with suppliers and implementation of e-business with suppliers-contractors (60% of purchase through e-business solutions).
- Possibility of electronic business with buyers and implementation of e-business with all interested buyers.
- Implementation of electronic catalogue system with ordering feature for buyers.
- Implementation of the system for management of rich data content.
- Use of up-to-date information and communication technology, web oriented applications and e-business standards.
- Readiness of Merkur for cooperation in global electronic distribution systems.

All fields of e-B2B cannot be implemented at one time; therefore the system must be developed step-by-step. Every project is assigned a priority, based on an analysis of available resources and technological possibilities. Higher priorities are assigned to projects which will bring higher business effects. With the implementation of new system, it is essential to integrate it with existing systems.

As the presented case study is focused on the wholesale and retail industry, the delivery area is the most demanding and extensive management process according to the SCOR model. Hence we can expect that practices like process documentation, integration, and measurement will have an important impact on SC performance [10].

Three different versions of the process were modelled: the process before IS implementation (AS-WAS); the current process (AS-IS), where several activities were automated; and the proposed redesigned process (TO-BE), where more radical changes are planned that require several organisational changes. In the continuation all three models are analysed by the use of simulations. For the first two models process maturity was estimated on the basis of the questionnaire, while for the last model sufficiently mature processes are a prerequisite for the proposed changes.

The benefits of IS implementation and increases in process maturity are analysed and discussed. The following criteria were used as indicators to evaluate the efficiency of the process:

- Process execution costs that can be used as a measure of necessary resources.
- Process time; that is the time between the beginning and the completion of the process; it includes payment etc.
- Lead time; that is the time between order placement and order fulfilment.

4.3 Process Before IS Implementation (AS-WAS)

The general description of the process is as follows: it began with an order or inquiry from a Customer. Based on the inquiry the Wholesaler prepared an offer that is reviewed by the Customer. If the Customer decided to place a purchase order (PO) it was sent to the Wholesaler that manually entered the PO into its information system and confirmed it to the Customer. If the goods were already available in the warehouse, proper documentation was prepared and sent to a Transporter that delivered the goods to the Customer. In the case of transit orders, the order was sent to a Supplier that arranged the delivery with the Transporter. The Customer received the goods. If necessary, a claim was made and dealt with by the Wholesaler. Finally, the invoice was sent and treated manually by the Customer. For transit orders the Supplier also had to send an invoice to the Wholesaler. All communications between the involved companies were made by ordinary mail, fax or phone. A detailed execution of the process can be seen from Figure 1.

The execution times and work costs of all activities were recorded. A 20-day simulation was performed with the Igrafx Process 2006 software. Based on business data, a new order is created every 30 seconds. Average lead times, process times and average work costs were monitored. The results of the AS-WAS model are shown in Table 1 and show average times of the whole process (process time), average lead time and costs, separately for all companies involved.

We estimated the maturity of processes by using the methodology presented above. Joint results of answers to the BPO questionnaire are shown in Table 2. Furthermore, we analysed the characteristics of maturity levels by interviewing the employees, who were most familiar with the SC processes. By combining these results we estimated that the maturity level of the process before IT implementation was between level 2 (Defined) and 3 (Linked).

4.4 Current Process (AS-IS)

In recent years, the AS-WAS process was automated and partly changed with IT implementation – a B2B portal Merkur Partner was implemented.

The Merkur Partner B2B shop enables selection and ordering of more than 177.000 items, which are divided in six sales programmes: ferrous and non-ferrous products, construction materials and wood, technical goods, consumer goods, chemical products, electrical and other installation materials.

At this time, the use of Merkur Partner is limited to contract partners, who have the insight into item data such as descriptions, prices and stock. They can also make orders or inquires and track them.

Merkur Partner includes many contents, which are organized in a practical and functional manner:

- *Login to Shop*: A username can be acquired only if it is approved by the person in Merkur responsible for the partner.
- *Catalogue of goods*: Items are structured into sales programmes and within them into product groups. When a group is selected, the list of group's items is displayed. Each item is presented with its attributes such as Merkur's article number, description, brand name, unit of measure, sales price for a partner, stock, lead time, additional description, buyer's article number, EAN code, picture and others.
- *Search engine*: Because of the very broad sales programme, the shop incorporates a search engine which enables an advanced search of items based on different criteria in the whole catalogue or just in a specific part of it.

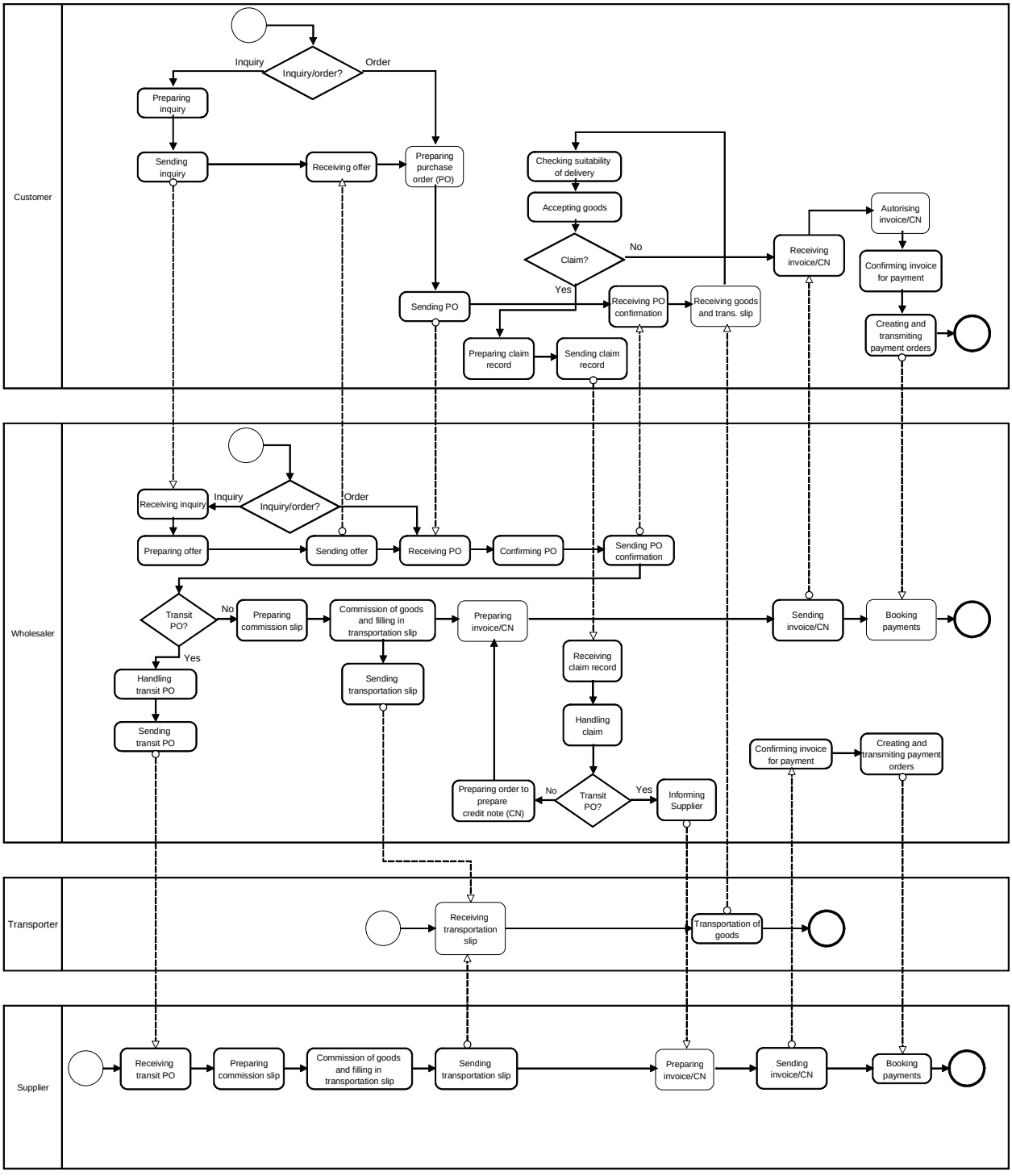

Fig. 1 AS-WAS process model

- *Ordering and inquiring*: Orders and inquires can be made by entering the quantities in a table view of items, in a detailed item insight or in a special quick ordering spreadsheet. Because of the strong integration between the KIS and Merkur Partner systems, insight into accurate order status is possible. This insight enables the tracking of goods on their distribution path through the supply chain.
- *Favourite subcatalogues*: The users of web shop can create their own subcatalogues and favourite groups of items. With this feature they can make orders and inquires much easier.
- *Business terms*: The business terms for web shop users are specified in a sales contract to which an annex defining e-business conditions is added.

- *Help*: The Help feature gives user a comprehensive explanation of the solution and assistance in certain business cases.
- *Contacts*: Any questions and unclear situation considering business relations with Merkur can be addressed to contact personnel assigned to each partner. The feature gives detailed contact personnel data including names, telephone and fax numbers and e-mail addresses.

With the implementation of Merkur Partner the process model has not considerably changed, the execution time of several activities has shortened (e.g. the execution time of the activity Sending inquiry was shortened from 2 to 1 minute). The number of customer inquiries is decreased in favour of higher percentage of direct POs since the customers have access to data about products and contractual conditions. The execution of an order is considerably faster for the Wholesaler (e.g. Confirming PO has been shortened from 5-10 minutes to 3-5 minutes) since it electronically receives the necessary data. After that the orders are automatically separated into orders from a warehouse and transit orders and necessary documents are created.

The simulation results of the AS-IS process are shown and compared to the results of the AS-WAS process in Table 1. As we can see the process and lead times were reduced and especially the costs were reduced considerably. However, the majority of the gains were realised by the Wholesaler.

Tab. 1 Simulation results for the AS-WAS and the AS-IS process in comparison

	AS-WAS time (in hr)	AS-IS time (in hr)	Change
Average process time	32.16	30.21	-6 %
Average lead time	29.63	27.57	-7 %
	AS-WAS costs (in €)	AS-IS costs (in €)	Change
Average Process costs	181	170	-6 %
Average Supplier costs	14	13	-6 %
Average Wholesaler costs	28	20	-26 %
Average Customer costs	42	38	-8 %
Average Transporter costs	105	105	0 %

We also estimated the increase in process orientation by using the same methodology. The results are shown in Table 2. The maturity level of the automated process has increased, especially in the »process view« of the employees. On the basis of the questionnaire and interviews we estimated that cooperation between company departments, vendors and customers was established. However, process management and processes in a SC are still marked relatively low. The overall maturity can be estimated to be on the 3rd level (Linked).

Tab. 2 Joint results of answers to the BPO questionnaire

		AS-IS	AS-WAS
A.I	Process View	4	2.8
A.II	Process Jobs	3	2.6
A.III	Process Management and Measurement	2.9	2.3
B.I	Processes in a SC	3	2.2

4.5 Redesigned Process (TO-BE)

Although the business process renovation has decreased the lead times and working costs, solely a better flow of information due to the automation of the process cannot bring all possible benefits. Therefore further changes in business processes, related to information technology introduction and organisational changes, are planned. The changes are relatively big, therefore a considerable support from all manager levels at all companies are necessary.

The following organisational changes were proposed:

- The B2B portal has to enable access to all relevant information for the customers (e.g. stock level at the supplier's side). All of them have to be technologically and organisationally prepared to use this kind of communication with the Wholesaler. That would eliminate the need for sending inquires and offers.
- Well-defined contracts should be signed with as many customers as possible. The contracts should define the selling conditions precisely enough, so that the sales process could be automated as much as possible.
- All information (both up and downstream) should be exchanged electronically, e. g.: purchase order from a Customer to the Wholesaler (without the need for offers or inquires); order confirmation (Wholesaler to Customer); transportation slip (Wholesaler – Transporter - Customer); transit order (Wholesaler - Supplier); invoice (Supplier – Wholesaler - Customer).
- Approval procedures (e.g. confirming PO) could be eliminated by the empowerment of employees and a more precise definition of business rules.

The redesigned model is shown in Figure 2. It is considerably simplified because several activities are no longer needed, while others are executed faster.

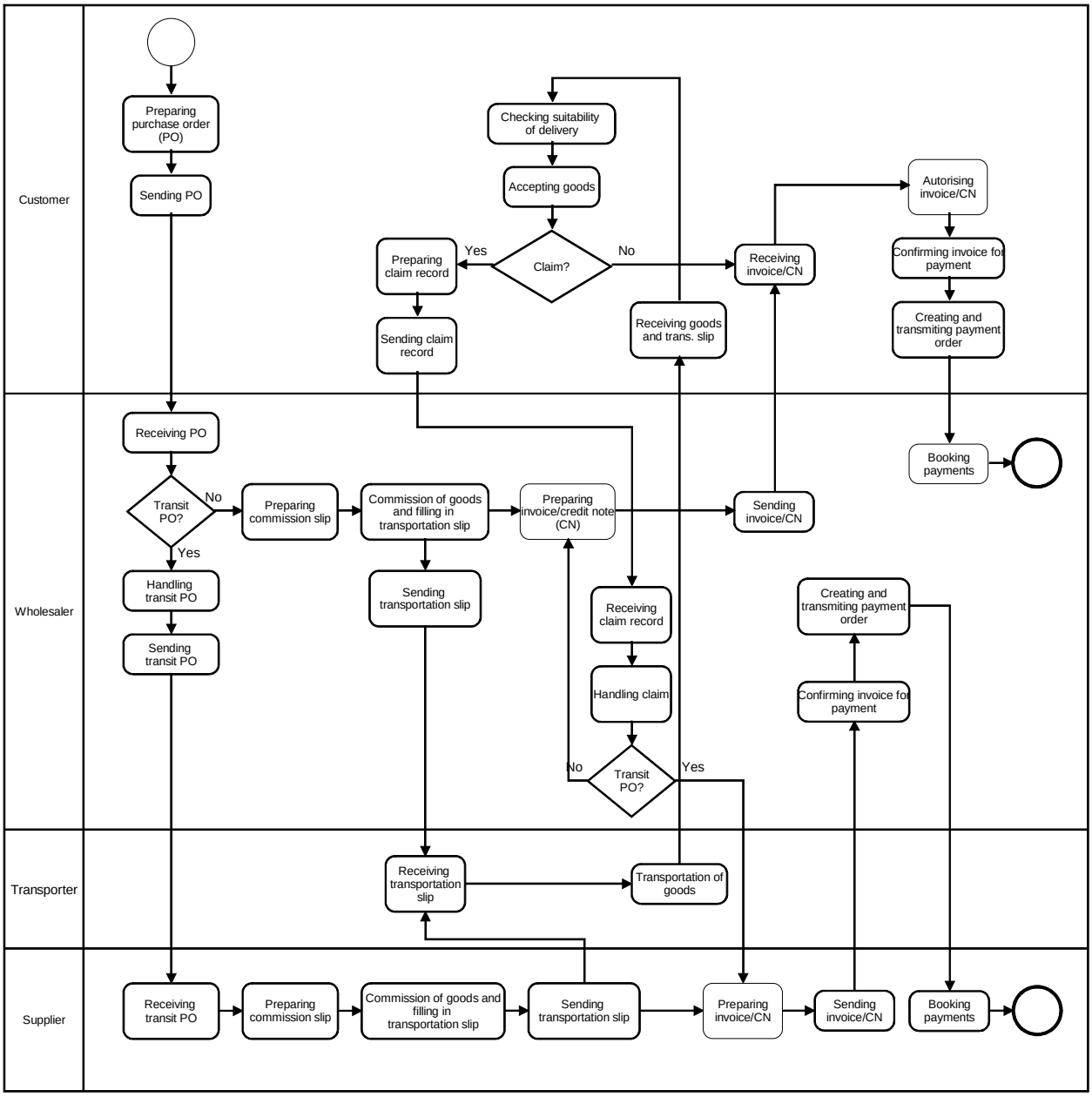

Fig. 2 Redesigned process (TO-BE) model

The simulation results for the TO-BE model are shown in Table 3. The changes enable an additional decrease in process execution lead times and costs. The savings are different for different companies – Transporter obtains the least benefits, while other three companies (especially the Wholesaler) obtain considerable benefits. It is important that changes are beneficial for all the companies involved, because this is a pre-condition for their willingness to participate in the project. Besides the Wholesaler, a strong interest for changes can be expected from customers as they can expect, in addition to decreased lead-times and costs, also a higher level of service and the decrease in the number of necessary complaints.

5 Discussion and conclusions

The case shows that BPM on the SC level brings benefits to all companies involved. The decrease in work costs and reduction in process and lead times begins with IT implementation and the increase in maturity. However, in order to further improve the process, more considerable organisational changes are needed (e. g. to eliminate the need for sending inquires and offers). The case study showed a considerable positive effect of such changes.

At the transition from the AS-WAS to the AS-IS process the changes were mostly present in the automation of certain activities. That increased process efficiency, along with the increase of process maturity to the 3rd (Linked) level. The most important is the improvement in process view that is the basis

for other characteristics of BPO. The reason for increase lies is that automation forced the employees to perform activities in a standard way and promptly. They also started to be aware of the fact that their work is part of a process, which has strenghthened cooperation between organisational units.

Tab. 3 Simulation results for the TO-BE process and a comparison with the AS-IS and AS-WAS process

	Time (in hr)	Change compared to AS-IS	Change compared to AS-WAS
Average process time	25.94	-14 %	-19 %
Average lead time	25.50	-8 %	-14 %
	Costs (in €)	Change compared to AS-IS	Change compared to AS-WAS
Average Process costs	142	-16 %	-22 %
Average Supplier costs	9	-29 %	-33 %
Average Wholesaler costs	8	-63 %	-73 %
Average Customer costs	25	-34 %	-39 %
Average Transporter costs	104	-1 %	-1 %

While the automation of the process can bring certain benefits in both increased process maturity and decreased costs, the simulation results clearly indicate that by far the highest savings can be realised from renovation and integration of processes. The simulation results confirm and expand the findings of previous researchers who reported considerably different savings from information sharing – from 0% to 35% of the total costs [32]. Simple introduction of IT can lead to the benefits closer to the lower figure; renovation and integration of processes accompanied with organisational changes to the higher figure.

There are two major proposals for the improvement of processes, as evident from the TO-BE process model and related description above: (1) elimination of sending inquires and offers and (2) approval procedures are simplified or eliminated. However, the proposed changes are not yet possible because they require some characteristics of the 4th maturity level (Integrated). Although BPO has improved in the process view, additional improvements are necessary especially in the area of process management, process jobs and processes in a SC.

To make the first proposal possible a Customer needs to have access to all relevant information (e.g. stock level at the supplier's side). The following characteristics of the 4th maturity level are required:

- Insight into stock level of the Wholesaler and the Supplier requires cooperation of all companies involved at the SC process level. The SC process has to be understood as a whole and not just within organisational boundaries.
- Long-term contracts have to be signed among partners in a SC. The increase in trust and long-term cooperation has to be established.
- IS has to be based on integrated SC processes and make unimpeded information flow possible.

For the second proposal empowerment of employees has to be applied. The following characteristics of the 4th maturity level are required:

- Jobs have to be transformed from simple to multidimensional tasks.
- Jobs will include more problem solutions and people will have to learn continuously.

On the other hand, the implementation of the proposed changes will enable an additional increase of BPO. For example, the application of SCM performance measures and management systems will be possible as a consequence of the integrated TO-BE model implementation. Companies will also have to think about changed organisational structures based on SCM procedures. They should appoint intra-organisational process owners and managers to take care of process efficiency. The implementation of such changes is considerably more difficult than the automation of existing processes.

With the elimination of sending inquires and offers the role of the companies involved will change. All companies in a SC will be stimulated to cooperate in a business process change project because the proposed changes bring benefits to all of them as proved by the results of simulations. However, transportation costs still remain almost the same. They could be reduced by an application of transport optimisation methods. That will have to be done in the future, because globalisation necessitates greater attention to logistics [2].

Efficient and effective achievement of the first levels (e.g. level 2 and 3) of business process maturity in a SC calls for the existing processes to be fully understood and documented. For the higher levels (e.g. lever 4 and 5) of SC maturity other BPM practices have to be applied. All benefits can be sustainable only when the integrated process is continuously managed and changed according to the business needs. BPM should not be considered as a one-time project of process change and IT implementation and metrics are not to be used only for analysing the current SC practices and benchmarking in the business process redesign project. BPM should be a permanent performance measurement, analysis and improvement effort. All companies involved in a SC have to be constantly alert and react proactively to

changes in business environment. SC processes have to be constantly measured and controlled. As competition is based on SCs at level 5 (extended), common process management for the entire SC has to be established.

Business process modeling and discrete-event simulation are valuable mechanisms for realizing the actual business value of B2B e-commerce. While most of the effects of IT implementation, improved flow of information, process integration and renovation can be observed and evaluated in a relatively short period of time, significant impacts of continuous monitoring, controlling and changing the performance of the SC processes can be expected as long-term outcomes of BPM.

The implementation of the presented concepts and possible benefits of the integration of a SC may vary on the current process maturity level in the participating companies (including the integration of ISs) and may differ in various industrial and service sectors. Nevertheless, the main SC process integration and management concepts, presented in the paper, can be applied with minor modifications regardless of the industry in question.

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